Cummins Perspective on Fuel Cells

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Cummins powers a broad range of applications with diverse requirements

- The world’s largest independent engine manufacturer
- Global manufacturing
- Broadest and most capable distribution and customer support network
- Powering more types of equipment in more markets than any other engine company

<table>
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<tr>
<th>Common Requirements</th>
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<tr>
<td>Fuel Efficient</td>
<td>Low Cost</td>
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<tr>
<td>High Power Density</td>
<td>Quick Start</td>
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<td>Transient Operation</td>
<td>Durability</td>
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Disruptive Trends

New technologies

Regulations

Competition

Emissions

Energy prices & availability

Globalization

Infrastructure
“Power of Choice” – Fuel Cell fit to Cummins applications

INTERNAL COMBUSTION ENGINE

HYBRID

BATTERY ELECTRIC

FUEL CELL ELECTRIC
Cummins turnkey electrified systems
Product and technology strategy

SERVICE & SUPPORT

SYSTEM OFFERINGS

Hybrid
Prime Mover
Gen
Traction
Battery
Fuel

Full Electric
Battery
Battery
Battery
Traction

Fuel Cell Electric
Fuel Cell
DC/DC
Traction

Battery

Battery Materials, MEA's & Cells

H₂ O₂
fuel cells
battery pack
power electronics
controls
motor generator
engines
accessories, cooling, wiring
storage

= integrated powertrain system

Fuel Cells

Components

CHARGING, CONNECTIVITY, HYDROGEN GENERATION & SUPPLY
# PEMFC vs. SOFC

<table>
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<tr>
<th>Proton Exchange Membrane (PEM)</th>
<th>Solid Oxide Fuel Cells (SOFC)</th>
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<tbody>
<tr>
<td>Pure H₂</td>
<td>H₂, CNG, LNG, Diesel, Gasoline, Ethanol, Methanol, Biofuels</td>
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<tr>
<td>Efficiency: 45-60%</td>
<td>Efficiency: 45-65% (80+ in CHP)</td>
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<tr>
<td>Temperature: 65-90°C</td>
<td>Temperature: 600-900°C</td>
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<tr>
<td>Emissions: Zero Emissions</td>
<td>Emissions: NOx &lt; 1ppm, CO &lt;100ppm, CO₂*</td>
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<tr>
<td>Instantaneous Startup &amp; Transient Response</td>
<td>Long Startup Time &amp; Slow Transients</td>
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<tr>
<td>Lower Initial Cost ($1000/kW → $50/kW)</td>
<td>Higher Initial Cost ($4000/kW → $1000/kW)</td>
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<tr>
<td>High fuel cost ($10/kg)</td>
<td>Very low fuel cost (NG: 2 cents/kWh)</td>
</tr>
<tr>
<td>Water Management, Humidification, Pressure Levels, H₂ storage &amp; availability</td>
<td>Start-up, Brittle Ceramics, Oxidation of Anode</td>
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Active exploration in PEMFC & SOFC

STATIONARY POWER – SOFC
- Higher sensitivity to operating cost
  - Efficiency
  - Fuel cost – natural gas preferred
- Data centers offer a large potential initial market

ON-HIGHWAY POWER – PEM OR SOFC
- Higher sensitivity to initial investment
- Requires distributed fuel availability
- Sensitive to fuel price, but not as much as stationary power
- Regulations (zero carbon zones) & subsidies are the key drivers
The project’s objective is to establish a public transport demonstration ecosystem in Costa Rica based on H2 generated from carbon-free, renewable energy and to measure its financial sustainability, business potential and its relevance to Costa Rica and the region. The first phase focused on demonstrating technical viability and the second phase will focus on demonstrating financial sustainability.
The lab’s initial focus will be on powering datacenters with natural gas powered fuel cells. The 20-rack environment in the lab simulates datacenter conditions to evaluate whether the fuel cells have the potential to improve efficiency, reduce emissions and cut costs.
Four Keys to Adoption

Technology
- Efficiency
- Durability/life
- Cold start
- Transient response

Regulations
- Public refueling stations
- Pipeline
- Hydrogen by-product from industries

Infrastructure Readiness
- Zero emission zones
- Government funding
- Incentives

Total Cost of Ownership
- Technology cost ($/kW)
- Fuel cost ($/kg)
- On-board storage system
- Refueling station cost
Cummins acquiring Hydrogenics

**TECHNOLOGY**
Adds both fuel cell and hydrogen generation equipment enabling Cummins to offer a full differentiated solution, from start to finish, seamlessly integrated for customers.

**EXPERTISE**
Adds a proven team with deep expertise and experience in fuel cell technology to Cummins.

**SPEED TO MARKET**
Hydrogenics’ long-track record of commercial success in a technology that is beginning to accelerate provides a springboard for Cummins into fuel cell markets, particularly in China and Europe.

**COLLABORATION**
Global gas leader Air Liquide will continue to be a minority investor, offering collaboration opportunities to strategically address the production of hydrogen, which has been a long-standing barrier to broad fuel cell adoption.

The acquisition remains subject to regulatory and shareholder approvals.
OUR ELECTRIFICATION VISION

We will be a leader in electrified power in all the markets we serve.